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STUDIES IN INDIAN FIBRE PLANTS

No. I. ON TWO VARIETIES OF SANN, CROTALARIA JUNCEA, L

BY

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ONE of the most important and most widely distributed annual fibre-yielding plants cultivated in India is *Sann* or *Sann-hemp—Crotalaria juncea*, L. It is grown in all the Provinces including Burma, but appears to be most widely cultivated in Madras, the United Provinces and in the Central Provinces. The extent to which it is cultivated as a fibre plant, for green manuring and for fodder purposes in all the Provinces of British India, except Bengal,[1] will be evident from the following extract from the *Proceedings of the Board of Agriculture in India* of 1909, pages 56 and 57, which gives the latest information on the subject.

"*Crotalaria juncea.*—The fibre of this crop does not compete with jute as does that of *Hibiscus cannabinus*, but in market value it is superior to both. *Sann*-hemp can best be grown in districts of moderate rainfall, and, therefore, does not compete with rice. It is, in some parts of India, frequently grown as a green manure crop before rice, and in others as a second crop in the same year after early rice for fibre. This rotation is advantageous, because *Sann* is a leguminous crop.

[1] Statistics of the area and production of *Sann* in Bengal are not at present available.

"The total acreage under the crop in the Bombay Presidency in 1906-07 was 23,700 acres, and in 1907-08, 25,470 acres. It is chiefly grown as a *kharif* crop for fibre, but also to a considerable extent as a green manure crop. In the Thana District, it is grown as a *rabi* crop in succession to early rice for fibre, which is used in making twine for nets by the fishermen.

"The returns for Madras give a total of over 300,000 acres; but it is known that only a very small proportion of this—a few thousand acres—is grown for fibre. It is most extensively cultivated for fibre in the Northern Circars, chiefly in the Amalapuram and Narsapur Taluks of the Godavari and Krishna Districts. In the rest of the Presidency with the exception of the Tinnevelly District, where some fibre is manufactured into extremely durable gunny bags, the cultivation of the crop is confined to the production of fodder.

"In Eastern Bengal and Assam this crop is largely grown in the Serajganj sub-division of the District of Pabna, where the estimated area is 33,900 acres. Generally it is grown in Serajganj on land which bears a jute crop in the same year. The area in Chittagong, where it is also grown as a *rabi* crop, decreased from 7,900 acres in 1906-07 to 1,600 acres in 1907-08. The total estimated area in Eastern Bengal and Assam is about 42,000 acres, and the estimated export of the fibre is 30,000 maunds. In this Province jute is much more important, but it is possible that the cultivation of *Sann*-hemp can be somewhat extended with profit, though as the water-supply for retting is limited in February and March, the months of its cutting, this would only be along the banks of rivers. In the Serajganj sub-division it is only grown for fibre quite close to water.

"A note by Mr. Clouston, the Deputy Director of Agriculture in the Central Provinces, on the cultivation of fibre plants in the Central Provinces, has been published in the *Agricultural Journal of India* (April 1908). The total area under *Sann* in the Central Provinces was 55,400 acres in 1907, which increased in 1908 to 85,044 acres. In Berar in 1907 the acreage was 32,360 and in 1908, 35,484. It is always grown as a pure crop and is cultivated

for its fibre chiefly, while the seed is a valued cattle food. It is generally believed that only one variety of *Sann* is grown throughout the Central Provinces and Berar. Retting costs a good deal. A suitable cheap machine to extract the fibre might be advantageous in extending the cultivation. The area in the Central Provinces has been nearly doubled during the last ten years. *Sann* cultivation is so profitable that the crop has been largely substituted for wheat. The cultivators understand that this crop is a hardy one and improves the condition of the land. It is grown to a small extent as a green manure crop, particularly for irrigated wheat and sugarcane. In the cotton tracts no extension of this crop can be expected, as cotton pays better. In the rice tracts, *Sann* could probably be profitably grown on much of the land which is planted with other second crops. The total quantity of *Sann*-hemp exported from the Province and the value of the same from 1904 to 1906 are shown below :—

Year.	Maunds.	Value.
		Rs.
1904-05	226,751	12,18,783
1905-06	201,402	10,82,534
1906-07	168,096	9,03,513
1907-08	271,727	14,60,532

"In the Punjab there were 57,000 acres under *Sann*-hemp in 1906 and 52,400 acres in 1908; the sub-montane tracts showed the greatest area. Very little is grown in the south-west of the Province. Throughout the Punjab, the crop is usually sown in very small plots, and very little is marketed. The crop is sown almost solely for fibre, but in the Hoshiarpur District, it is estimated that one-tenth of the crop was grown for green manuring. The practice of green manuring with *Sann* is, however, rare at

present. The retting and cleaning of the fibre are regarded as very tedious and troublesome processes. Having regard to these troubles, the crop is considered to be less remunerative than some other crops. The imports of *Sann*-hemp fibre into the Punjab in 1906-07 were 15,382 maunds and in 1907-08, 20,984 maunds, almost entirely from the United Provinces. The exports amounted to only 4,078 maunds in 1906-07 and 2,584 maunds in 1907-08.

"The returns of the United Provinces show an area in 1906-07 of 133,000 acres of hemp, which include both *Hibiscus cannabinus* and *Sann*-hemp: and in 1907-08 of 158,000 acres. Practically the whole of this area is devoted to *Sann*-hemp. It is grown for fibre and almost universally as a border crop with *kharif* crops, the produce being worked up by cultivators into ropes for home use. The export is, therefore, a small part of the produce. The trade returns of the United Provinces for 1906-07 show practically no imports of the hemp, but exports aggregating 400,000 maunds, valued at 22 lakhs of rupees, and in 1907-08 of 409,800 maunds, valued at Rs. 26,17,000; most of this is *Sann*-hemp. There is a steady trade to Calcutta and a very fluctuating trade to Bombay. The crop is a well-recognized feature of the local agriculture, and the trade in fibre is an organized one. The area generally responds to the prices offered.

"This crop does well in the Tavoy District of Tenasserim. It is grown there after paddy. The estimated area is about 400 acres in Lower Burma. The fibre is used for fishing nets. It is very doubtful whether there will be any great development of this crop, unless the Department of Agriculture, Burma, succeeds in introducing it for green manuring."

The export trade in *Sann*-hemp fibre appears to be most important in the United Provinces, the amount exported in 1907-08 being valued at twenty-six lakhs of rupees.

Considerable attention appears to have been paid to *Sann*-hemp in India towards the close of the eighteenth and the beginning of the nineteenth century by several writers, including Roxburgh and Wisset, and the earlier information on the subject is

summed up by Royle.[1] Watt[2] has brought the subject up-to-date and has included in his account of *Crotalaria juncea*, the recent work done at the Calcutta Botanical Gardens. Royle seems to have been the first to raise the question of the existence of more than one fibre-yielding species of *Crotalaria* in cultivation in India. It appears that specimens of cordage of excellent quality, and said to be made of Jubbulpore hemp, were sent to the 1851 Exhibition by Messrs. Harton & Co., rope-makers of Calcutta. Samples of this fibre, obtained by Royle in 1853, proved to be equal if not superior to Russian hemp and were valued at £30 to £35 a ton. He considered the plant which gave rise to this fibre was *Crotalaria tenuifolia*, R. This determination seems to have been made on the authority of Falconer,[3] to whom a specimen was referred. Wight and Arnott,[4] however, regarded *C. tenuifolia* as a variety of *C. juncea*, the plant affording the well-known "*Sann*-hemp" of commerce. That Falconer's diagnosis was incorrect will be evident from Roxburgh's description of *C. tenuifolia*,[5] which is as follows :—

"*C. tenuifolia* R. Perennial, ramous, straight-furrowed, hoary. *Leaves* linear, sericeous underneath. *Stipules* minute, subulate. *Racemes* terminal. *Legumes* sessile, clavate, many-seeded.

"A native of Coromandel. In the Botanic Garden it is perennial, growing to the height of nine feet, with numerous, slender, furrowed, straight branches, which are again more ramous at the top; during the cool season each twig ends in a long raceme of large yellow flowers and the seed ripens in two months."

Jubbulpore hemp, on the other hand, is a tall straight annual with linear lanceolate leaves, while *C. tenuifolia* R. is described by Roxburgh as a branched perennial with linear leaves and a native of Coromandel.

Nothing seems to have been done in India on the botany of the plants yielding *Sann*-hemp until 1902 when the source of the

1 Royle, *The Fibrous Plants of India*, London, 1855, p. 271.
2 Watt, *The Commercial Products of India*, London, 1908, p. 430.
3 *Proceedings of the Agri-Horticultural Society of India*, April, 1851.
4 Wight and Arnott, *Prod.* i, 185.
5 Roxburgh, *Flora Indica*, Calcutta, 1874, p. 546.

Sann-hemp of commerce was taken up by the Calcutta Botanical Gardens. Watt[1] sums up the results of these experiments as follows :—"Recent experiments conducted at the Royal Botanic Gardens, Calcutta, support the belief that all the trade qualities represent seasons of growth or methods of separation of fibre, and not botanical forms." Further, Watt states : "It would seem from the Calcutta experiments that all the forms hitherto grown from seed procured from such remote localities as Vizagapatam, Jubbulpore, Pillibhit, etc., have resulted in plants of varying stature, size of flower, etc., but in no structural departures that could justify even varietal positions being assigned to them." Thus it would appear proved that there is only one species of *Sann*-hemp widely cultivated in India, namely, *C. juncea*, and that Royle's view that Jubbulpore hemp is *C. tenuifolia* is incorrect.

From the *kharif* season of 1906 to the present time many sowings of *Sann*-hemp from various parts of the Central Provinces, including Jubbulpore, have been made by us at Púsa. Some of these have been on a large scale either for green manuring, for fibre or for seed. Observations have also been made in the *Sann*-hemp fields of the Central Provinces on the botanical composition of the crop.

The first sample of Jubbulpore hemp was sown in the *kharif* of 1906, and single plants of this were selected for seed for the following year. In 1907 and 1908 the sowings were repeated, and from the 1908 harvest single plants from each of the plots were selected for carrying on the cultures in 1909. Thus Jubbulpore hemp has been grown for four seasons, and from Púsa grown seed for three seasons. No change has been observed in the behaviour of the cultures—either in botanical characters, in habit of growth, length of stem or in earliness. Further, all the pure line cultures have shown themselves to be identical in all respects, and Jubbulpore hemp seems to contain only one type.

Consignments of *Sann*-hemp seed were obtained from the Agricultural Department of the Central Provinces in 1906 and again in 1909, and the produce of these was compared with the cultures of

1 Watt, l. c.

Jubbulpore hemp grown at Púsa. No differences were observed, and it appeared likely that only one variety of this crop is generally cultivated in the Central Provinces.

In 1908, our attention was arrested by the marked difference in appearance between the seedlings on a field sown with Central Provinces *Sann*-hemp and those in a field sown with the local *Sann*-hemp. A portion of each was allowed to seed and further differences were noted in the ripe plants. Accordingly the seed of a large number of single plants of each of these fields was saved and sown separately in 1909 side by side and under uniform conditions. Observations were also made on a field divided into three parallel strips and sown with local seed, seed from the third generation at Púsa-grown Jubbulpore hemp and with seed freshly imported from Hoshangábád. No differences were observed between the Púsa-grown Jubbulpore hemp and that from Hoshangábád. These proved identical.

There were marked differences, however, between the local *Sann*-hemp and that from the Central Provinces, and these differences could be easily traced from the seed to the mature plant.

The seeds of the two varieties are quite distinct. The seeds of the local *Sann*-hemp are small, shiny and quite black ; those of the Jubbulpore hemp are much larger, duller and bluish black or greyish. The differences in time of germination are equally marked. The larger seeds of the Jubbulpore variety germinate with remarkable rapidity, and the seedlings appear above ground from 12 to 24 hours earlier than those of the local variety when both are sown at the same time and under equal conditions. The start gained by the Jubbulpore variety is never lost throughout the whole of the after-development of the plant and the Central Provinces variety is always larger, taller, and earlier than the local. In addition to the speed of germination and of subsequent growth the characters of the seedlings of the two varieties are quite distinct. The average length of the seed-leaves of the local seedlings is 22 mm., that of the Jubbulpore variety 30 mm. On account of this difference the appearance of the two sets of seedlings is very different. Apart from the size of the seed-leaves, there are other distinctions. The

under-surface of the cotyledonary leaves of the local variety is reddish and this reddening is also to be seen on the stems. Further, both the under-surface of these leaves and the stems are hairy. In the case of the Jubbulpore variety the under-surface of the first leaves and the stems are quite green and glabrous. Seven weeks after sowing, the local plants measured on the average 114 cms. in height, while the Jubbulpore plants were 157 cms. on the average. After the seedling distinctions, it is in the branching of the two varieties that the greatest differences are to be seen. The local variety generally branches about four feet above the ground; the branches are long and spreading with secondary and often tertiary arms, the whole forming a dense canopy. The Jubbulpore variety branches about eight feet from the ground, throwing off a few erect parallel shoots with little or no secondary branching and no canopy is formed. The local variety is late and yields abundance of flowers and seed, while the Jubbulpore variety flowers much earlier and forms but few seeds.

The above differences are summed up in the following table :—

	Local variety.	Jubbulpore variety.
1.	*Seed.* Small, shiny, black.	Large, dull black or greyish.
2.	*Seedlings.* Germination slow, seedlings small with reddish downy cotyledonary leaves and stems.	Germination rapid. Seedlings large with green glabrous cotyledonary leaves and stems.
3.	*Plants.* Short, late maturing with many-flowered spreading branches beginning at a point about four feet from the ground.	Tall, early maturing with a few short sparsely flowered parallel branches beginning at a point about eight feet from the ground.

The general habit differences at flowering time can be seen in Plate I. The rows on the right are pure line cultures of Jubbulpore hemp. Those on the left are similar cultures of the local variety. In Plate II the same varieties are again shown, but in this case the local variety is on the right. The much shorter growth of both varieties is due in this case to late sowing. In all cases but poor development is obtained with *Sann*-hemp when sowing is deferred till the middle of the monsoon. To obtain the best results

PLATE I.

PURE LINE CULTURES OF LOCAL AND JUBBULPORE SANN AT PUSA.

PLATE II.

THE DWARFING EFFECT OF LATE SOWING ON SANN.
The left-hand plot is Jubbulpore *Sann*, the right-hand plot the local variety.

both for green manure and fibre, it is necessary to sow *Sann*-hemp at Púsa either on the first monsoon showers early in June or preferably on the *chota barsat* showers in the second half of May. Late sowing unfavourably affects the Jubbulpore variety to a much greater extent than the local. A fair crop of the local variety is obtained even in late sowings.

There is no doubt that there are at least two absolutely distinct varieties of *Sann*-hemp cultivated in India, and that the differences given above are inherent in the varieties. The following excellent description of *Crotalaria juncea* given by Roxburgh in *Flora Indica* (p. 545), applies to both varieties :—

"*Stem* annual, straight, from four to eight feet high, or even more, striated from the insertion of the leaves, a little downy, towards the top branchy, and, when the plant stands single, more so. *Leaves* scattered, short-petioled, lanceolate, obtuse, with a small bristle-like point ; both sides covered with soft, silver-coloured hairs, from two to six inches long, and from half an inch to one and-a-half broad. *Stipules* subulate, small. *Racemes* terminal, single. *Bractes* oval, one-flowered. *Flowers* numerous, papilionaceous, large, of a beautiful bright yellow. *Calyx bilabiate ;* the *upper lip* two-cleft ; the *under* one three-parted in the middle, and there gaping ; at the apex the segments are united. *Banner* obtuse, erect. *Wings* oblong, obtuse. *Keel* much pointed, slightly twisted at the apex and closely shut. *Filaments*, their lower half united into one body, with a fissure down the upper side, which has a circular gape at the base ; extremities free, and alternately shorter. *Anthers* on the shorter filaments linear, on the longer ovate, and two lobed. *Legumes* sessile, club-shaped, downy, from one to two inches long. *Seeds* numerous, kidney-formed."

The occurrence of two sorts of stamens in the flowers of this species was observed by Roxburgh who describes them as follows :—

" There is something very interesting in those two sorts of stamens. If a flower is opened some time before the natural time of its expanding, which must be just before any of the anthers

burst, the filaments of the subulate set will then be found considerably longer than those of the round set, and the stigma will then be about the same height; these long anthers come to maturity long before the round ones, and about the time the stigma is among them; but the style continues to grow longer, by which means the bearded stigma pushes on with it much of the pollen from the long anthers whose filaments do not lengthen any more: but those of the round ones now begin to lengthen, pushing their anthers considerably beyond the apices of the linear set, and even with the stigma; by this economy they come in contact with it before or about the time of their maturity. These changes I have found most conspicuous in *Crotalaria juncea* and *pentaphylla*, whose flowers are very large, every part being easily seen with the naked eye."

The fact that the subulate stamens shed their pollen in the bud all round the style and stigma combined with the closely shut and twisted keel would appear to greatly favour self-pollination in this species and to render natural crossing rare. If this supposition is borne out by further observation on the behaviour of the produce of pure lines of both varieties grown next to next and natural crossing is found to be exceedingly rare, then it is likely that few types of this species will be found in cultivation. The absence of crossing would also explain the remarkable purity observed in the crop as grown in the Central Provinces. No evidence of natural crossing was observed in the pure lines of both varieties grown at Púsa in 1909.

The two varieties have been compared at Púsa for green manuring purposes. The rapid germination and growth of the Jubbulpore *Sann* are great advantages over the local variety in years of short rainfall, or when it is essential to establish the crop on the early pre-monsoon showers. This rapid growth also prevents the early growth of weeds. At a much later period of growth and after the green manuring stage these advantages to a great extent disappear and are even reversed. The branching of the local variety before flowering time forms a dense canopy under which weeds are killed out, while the more erect habit of the Jubbulpore

variety enables a bottom growth of weeds to gradually become established unless the hemp is very thickly sown. In 1909, weighments were made of the green crop 53 days after sowing, just before being ploughed in for green manure. In appearance the plots seemed very different, and it was expected the weight of the taller Jubbulpore variety would be much the greater. Actual weighments, however, showed that the difference was very slight. The local variety gave 7 maunds 15 seers per 2,000 sq. feet, the Jubbulpore variety 7 maunds 35 seers, an increase of only 40 pounds. The stubble of the local variety was more weedy than that of the Jubbulpore hemp, but, as has been stated above, this difference is reversed if the plants are allowed to grow for fibre and seed. As far as green manuring is concerned, the advantage is with the Jubbulpore variety, especially if the sowings have to be made early. There is one possible disadvantage, however. The variety from the Central Provinces produces but a poor crop of seed in Bihár, and it remains to be proved whether it would be found cheaper to import fresh seed every year and to use the land, which would otherwise have to carry the crop for seed, for the growth of a *rabi* crop.

The great advantage of *Sann*-hemp as a green manure in improving the quality and productiveness of the soil of the alluvium, although often referred to, does not appear to be fully realised and sufficiently widely adopted in practice. This appears to be due to the manner in which the crop is grown and ploughed into the soil. It often happens that a difficulty is experienced in getting the crop rotted and thoroughly incorporated into the soil before the cessation of the monsoon leading to great damage to the succeeding *rabi* crop through white-ants and through a too open texture caused by the undecomposed stems. These objections are easily overcome by a little care and forethought. To be successful as a green manure and to give time for thorough decomposition and subsequent incorporation of the crop, it should be sown in a previously well prepared and well aerated seed bed preferably on the showers of May or not later than the earliest showers of June. The risk of withering is small as the tap root grows so rapidly that

it quickly reaches the lower soil moisture. By the end of the first week in July the crop can be ploughed in, and before the end of September it will have disappeared entirely. July 15th is the very latest safe date for ploughing in at Púsa, and it is preferable not to delay the ploughing in beyond July 7th. The effect of a successful green manuring is extraordinary. The texture and colour of the soil are altered, heavy lands become easily workable and readily yield a good tilth. The effect on the next few crops is wonderful both in luxuriance and also in rapidity of growth. On tobacco, the land for which is left fallow in the monsoon, the effect is greater than that of a heavy dressing of farm yard manure. In Plate III are shown two plots, the left green manured with *Sann*, the right with old tobacco leaves and stems. The photograph was taken on November 10th, and both plots were transplanted on September 20th. The increased growth of the *Sann* plot is extraordinary, and there seems no reason why this cheap manure should not be much more extensively employed in tobacco-growing in Bihár.

Besides the advantage in rapid growth the *Sann* plots of tobacco at Púsa in 1909 gave a much greater yield per acre than the plots manured with cattle dung, rape cake or old tobacco stems. Further, the green manure plots ripened off earliest of all, and the texture and colour of the cured product were not unfavourably affected by the manurial treatment. Grown after *Sann* it is possible to raise in Bihár large crops of tobacco which ripen off evenly in the second half of December. This admits of the curing being carried out in January before the hot dry west winds set in.

With regard to the relative value of both varieties for fibre in Bihar, it is too early to venture a final opinion. The tall straight unbranched habit of the Jubbulpore hemp is, however, an obvious advantage for fibre purposes over the local variety. A sample of the Jubbulpore plant was submitted to Mr. R. S. Finlow, the Fibre Expert to Eastern Bengal and Assam, who has also examined single plants of both varieties. His report is given below :—

"A comparative examination of Jubbulpore hemp, grown in the Botanical area at Púsa, and ordinary *Sann*-hemp,

THE EFFECT OF GREEN-MANURING WITH SANN ON TOBACCO.
The plot on the left was green-manured with *Sann*, the plot on the right with old Tobacco leaves and stems.

obtained from the neighbourhood of Púsa, gave the following results :——

	Jubbulpore Hemp.	Local Hemp.
Less on hydrolysis (1 hour in 1% potash) ...	9·75%	13·85%
Cellulose	79·60%	74·80%
Average length of ultimate fibres ...	5·3 mm.	3·98 mm.

These figures, which require further confirmation from samples produced under more nearly identical conditions, indicate a considerable superiority of Jubbulpore hemp over local *Sann*, both from the point of view of strength and of durability. They are supported by the fact that, on being tested, the Jubbulpore hemp showed markedly greater tensile strength than local *Sann*."

The occurrence of two such distinct varieties of *Sann*-hemp in India as those described above shows the desirability of conducting a survey of the crop grown in the various Provinces of India. Accordingly, steps have been taken to collect and grow at Púsa samples of this crop from all the typical tracts in which its cultivation is of importance. Possibly other varieties will be found in addition to the two described in the present paper.

PUSA,
November 13*th*, 1909.